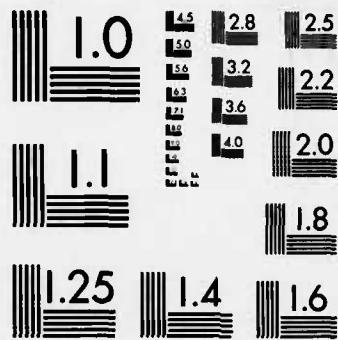


AD-B155 853L ENHANCEMENTS MADE TO THE TRIDENT ASSIGNMENT PROGRAM(U) 1/1
LOGICON INC SAN PEDRO CA STRATEGIC AND INFORMATION
SYSTEMS DIV J K REEDER 24 JAN 91 DNA-TR-91-16
UNCLASSIFIED DNA001-87-C-0177 F/G 16/2 CTRL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-B155 853



DNA-TR-91-16

(2)

Enhancements made to the Trident Assignment Program

**Logicon, Incorporated
Strategic and Information Systems Division
P. O. Box 471
San Pedro, CA 90733-0471**

24 January 1991

Technical Report

CONTRACT No. DNA 001-87-C-0177

Further dissemination only as directed by the
Defense Nuclear Agency, 6801 Telegraph
Road, Alexandria VA 22310-3398, 4
February 1991 or higher DoD Authority.

This work was sponsored by the Defense Nuclear Agency under RDT&E RMC Codes
B4697 C RO RB 00005 NASF 2430 A and B4697 C RO RB 156 NASF 2430 A 25904D.

**DTIC
ELECTED
JUN 27 1991
S B D**

Prepared for:

**Defense Nuclear Agency
6801 Telegraph Road
Alexandria, VA 22310-3398**



91 6 21 095

91-03158



| REPORT DOCUMENTATION PAGE | | | Form Approved OMB No. 0704-0188 |
|---|--|--|------------------------------------|
| <p>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.</p> | | | |
| 1. AGENCY USE ONLY (Leave blank) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED | |
| | | Technical - 870808 - 910124 | |
| 4. TITLE AND SUBTITLE | | 5. FUNDING NUMBERS | |
| Enhancements made to the Trident Assignment Program | | C - DNA 001-87-C-0177 PE - 62715H PR - R0 TA - RB, RZ WU - DH039910 | |
| 6. AUTHOR(S) | | 8. PERFORMING ORGANIZATION REPORT NUMBER | |
| Jerold K. Reeder | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) | | 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | |
| Logicon Incorporated Strategic and Information Systems Division P.O. BOX 471 San Pedro, CA 90733-0471 | | Defense Nuclear Agency 6801 Telegraph Road Alexandria, VA 22310-3398 NASF/Griffin | |
| 10. SPONSORING/MONITORING AGENCY REPORT NUMBER | | 11. SUPPLEMENTARY NOTES | |
| DNA-TR-91-16 | | This work was sponsored by the Defense Nuclear Agency under RDT&E RMC codes B3860 874697 R0 RZ 00003, B4697C R0 RB 00005 NASF 2430A, B4697C R0 RB NASF 2430A 25904D. | |
| 12a. DISTRIBUTION/AVAILABILITY STATEMENT | | 12b. DISTRIBUTION CODE | |
| Further dissemination only as directed by the Defense Nuclear Agency, 6801 Telegraph Road, Alexandria, VA 22310-3398, 4 February 1991, or higher DoD authority. | | | |
| 13. ABSTRACT (Maximum 200 words) | | | |
| The Trident Assignment Program (TAP) is part of a Trident missile planning system developed by the British Royal Navy. Changes were made to the TAP program including the incorporation of a launch timing and fratricide deconfliction capability. The capability will minimize the timespan of launches, minimize the timespan of impacts, or minimize occurrences of fratricide within a fixed-rate schedule. Other minor enhancements were also made to the missile assignment portion of TAP. | | | |
| 14. SUBJECT TERMS | | | 15. NUMBER OF PAGES |
| Mission Planning Missile Application Timing and Deconfliction | | | |
| | | | 16. PRICE CODE |
| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
| UNCLASSIFIED | UNCLASSIFIED | UNCLASSIFIED | SAR |

SUMMARY

This report describes the updates and enhancements incorporated into the Trident Assignment Program (TAP). TAP is computer software used by the British Ministry of Defence for creating Trident II strategic plans. The primary enhancement performed under this contract was a capability to schedule missile launches.

Capabilities of the scheduling function include minimizing the time needed to launch all the missiles from each boat, minimizing the time needed to detonate all reentry bodies (RBs), and launching missiles at a fixed rate. Fratricide—that is, one nuclear detonation destroying another weapon before it can detonate—is a major consideration when scheduling. TAP minimizes fratricide by scheduling to avoid it where possible.

Enhancements were also performed to TAP's missile assignment processing. These included updating the program with the latest Trident II data, improving user controls over the number of hits a target receives, and processing relocatable targets.

| | |
|--------------------|-------------------------------------|
| Accession For | |
| NTIS GRA&I | <input type="checkbox"/> |
| DTIC TAB | <input checked="" type="checkbox"/> |
| Unannounced | <input type="checkbox"/> |
| Justification | |
| By _____ | |
| Distribution/ | |
| Availability Codes | |
| Dist | Avail and/or Special |
| F.5 | |



TABLE OF CONTENTS

| Section | Page |
|---|------|
| SUMMARY | iii |
| LIST OF FIGURES | v |
| 1 INTRODUCTION | 1 |
| 2 TAP.3 ENHANCEMENTS | 3 |
| REHOSTING TAP TO VAX COMPUTERS. | 3 |
| REPLACING TRIDENT I WITH TRIDENT II. | 4 |
| UTILIZING DUMMY STRAP. | 4 |
| RELOCATABLE TARGET PROCESSING. | 5 |
| MANDATORY MULTIPLE HITS. | 6 |
| MODE 1 SCHEDULER. | 6 |
| Exclusion Periods and Cover Pairs. | 7 |
| Mutual Cycles and Launch Delays. | 9 |
| Sequence the Sorties for Scheduling. | 10 |
| Assign Launch Times. | 10 |
| Compute Probability of Fratricide. | 11 |
| 3 TAP.4 ENHANCEMENTS | 12 |
| MODE 2 SCHEDULER. | 12 |
| Fixed Launch Rate. | 13 |
| Inter-Package Delay Timing. | 13 |
| Sub-Packages. | 13 |
| Preordered Sorties. | 14 |
| Relaunch Windows. | 14 |
| Disregard Certain Cover Relationships. | 16 |
| MODE 1 SCHEDULER. | 16 |
| Eliminating Overlapping Launch Times. | 16 |
| Disregarding Certain Cover Relationships. | 16 |
| 4 MAINTENANCE | 17 |
| 5 SUPPORT AND ADVICE | 19 |
| TRAINING. | 19 |
| NWEM SUPPORT. | 19 |
| TECHNICAL INTERCHANGE. | 19 |
| 6 CONCLUSION | 21 |
| APPENDIX GLOSSARY OF TERMS | 22 |

LIST OF FIGURES

| Figure | | Page |
|--------|-----------------------------------|------|
| 1 | Major components of TAP | 1 |
| 2 | TAP development schedule | 2 |
| 3 | Accessibility domain geometry | 5 |
| 4 | Relocatable target scenario | 6 |
| 5 | Mandatory multiple hits example | 7 |
| 6 | Stayout zone geometry | 8 |
| 7 | Fratricide filter test | 9 |
| 8 | Mutual cycles example | 10 |
| 9 | The fratricide function | 11 |
| 10 | Package and sub-package timelines | 14 |
| 11 | Package and sub-package functions | 15 |
| 12 | Relaunch windows | 15 |

SECTION 1

INTRODUCTION

The Trident Assignment Program (TAP) was developed for the British Royal Navy under a prior contract, DNA001-84-C-0297. In that effort, the Joint Strategic Target Planning Staff's (JSTPS) missile application program, M202, was customized to meet the needs of the Royal Navy.

TAP is a full-featured missile planning program for the Trident II system. Given aimpoints, a Trident arsenal, and direction from the planner, it can assign specific missiles and warheads to specific aimpoints and schedule the launches of those missiles. When assigning missiles to aimpoints, TAP attempts to cover highly valued and critically important aimpoints, forgoing lesser DGZs (desired ground zeros) if necessary. TAP selects launch times that minimize fratricide, yet satisfy other planner objectives prescribing bounds on the schedule. Figure 1 shows the major components of TAP and how they work together.

Work under the current contract primarily involved the development of the scheduling capability. A portion of the processing was derived from the Advanced Missile Model (AMM), a program used by the Air Force Center for Studies and Analyses. The fratricide calculations used with TAP were from the Nuclear Weapons Environment Model (NWEM), a DNA program. The other

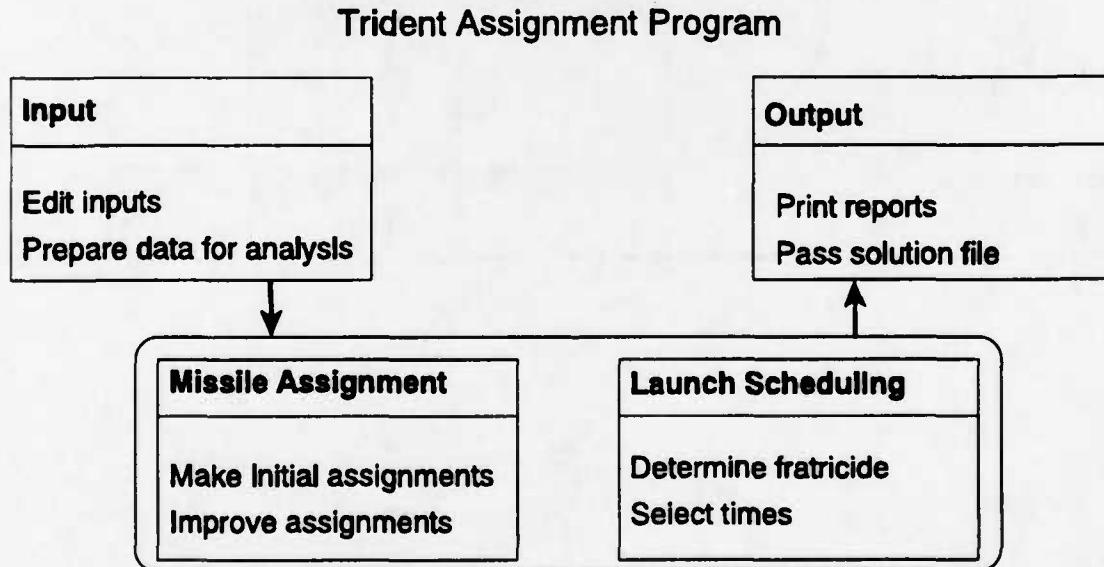


Figure 1. Major components of TAP.

portions of the scheduling code were developed in concert with the Director General Strategic Weapons Systems (DGSWS) organization of the British Ministry of Defence.

Other upgrades were made to TAP under this contract, as well. Many changes were made to the assignment portion of the program to tailor it more directly to British needs. These will be described in later portions of this document.

The schedule under which this effort was performed is shown in Figure 2. There were two primary deliveries: TAP.3 and TAP.4. In the following sections of this report, the tasks performed for each of these, as well as the other support work provided to DNA and DGSWS, is described. Work on this contract was accomplished on schedule and within budget.

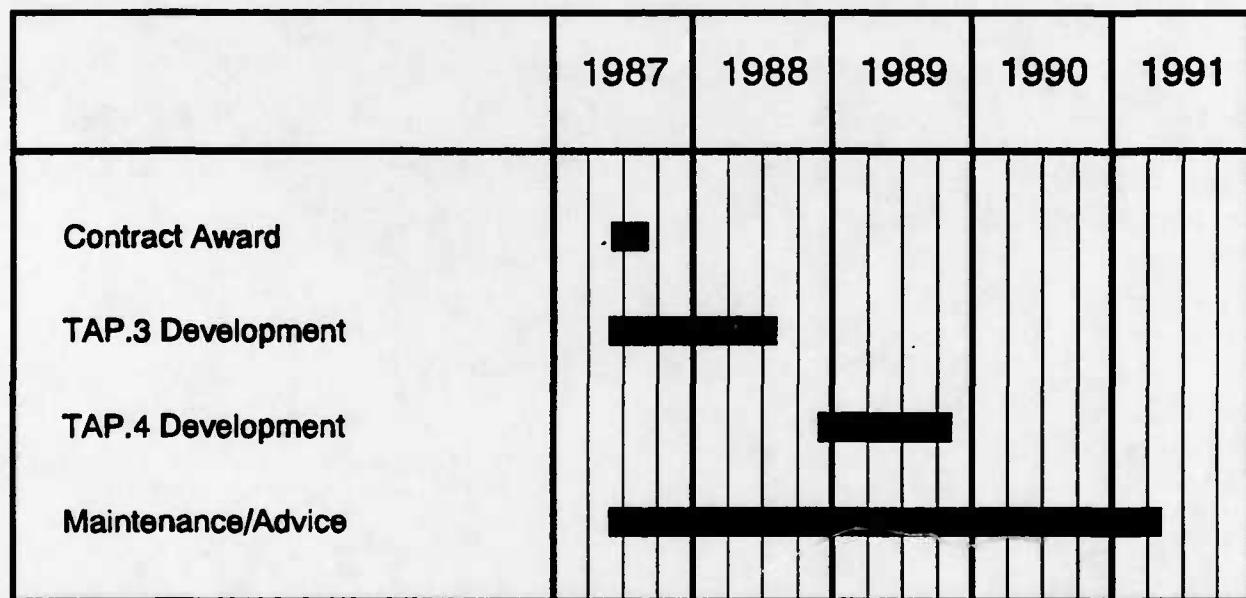


Figure 2. TAP development schedule.

SECTION 2

TAP.3 ENHANCEMENTS

The enhancements provided for the third major version of TAP included:

- rehosting the program from the IBM mainframe and Perkin-Elmer computers to Digital Equipment VAX machines
- replacing Trident C4 code of the earlier versions with Trident D5 processing
- including DGSWS's Dummy Simplified Trident Rapid Achievability Predictor (STRAP) accessibility model instead of STRAP for determining achievability
- introducing special processing techniques for relocatable targets
- multiple hitting of specified DGZs in preference to hitting other DGZs singly
- scheduling sortie launches that minimize the span of time required to launch the missiles, without exceeding fratricide limits

Each of these enhancements is described in the following sections.

REHOSTING TAP TO VAX COMPUTERS.

Initially, TAP was developed on an IBM mainframe compatible with the TRICOMS computer system at the Strategic Air Command. The first version of TAP was converted to run on the DGSWS Perkin-Elmer system. The second version of the program, developed under a prior contract, was also hosted on the Perkin-Elmer computer.

Logicon ported the code to a third platform, the VAX, as the first task in preparing TAP version 3. This conversion involved modifying file names, preparing control language to execute the program, and changing source code that was incompatible with the VAX.

After these tasks were performed, a wide range of tests was run to compare the results achieved on the IBM with those on the VAX. Once TAP was baselined on the VAX, the other development tasks commenced.

REPLACING TRIDENT I WITH TRIDENT II.

The first versions of TAP were delivered with the capability of assigning Trident C4 missiles. This was because programs to model D5 missiles had not yet been developed by the Naval Surface Warfare Center. The initial C4 capability allowed the British planners to begin examining the processes of missile planning while awaiting the final products.

With TAP.3, the Trident II models became available, so the program was updated. The primary impact on the program was a change in nomenclature on the inputs and reports. Minor changes were required in the processing to invoke the Trident II achievability model.

UTILIZING DUMMY STRAP.

For security reasons, DGSWS was unable to release STRAP for D5 to Logicon. To allow software development and testing to continue, DGSWS therefore prepared a "Dummy STRAP" that would simulate missile trajectories in an unclassified fashion. This module was incorporated into TAP for use during development and acceptance testing.

One portion of STRAP not replicated in Dummy STRAP was the "domain" computation. A domain is an elliptical region centered on the first DGZ selected for a sequence, as shown in Figure 3. Its area includes all other DGZs that might possibly be included with the first DGZ in a complete sequence. Its major and minor axes provide a quantitative estimate of the relative fuel used for performing downrange maneuvers vs. crossrange ones. The size and shape of the ellipse are determined by azimuth, range, and weapon configuration. These domain factors are used extensively in selecting DGZs for use in a sequence, and for ordering those DGZs. Because this domain data was not provided, Logicon functionalized it by executing TRAP.2, JSTPS's Trident II Rapid Accessibility Program, thousands of times, for a wide range of azimuths and flight distances. The resulting data was fit to curves and incorporated into TAP.3. Because the domain data is used as a guide rather than an assignment acceptance criterion, minor future changes to the missile performance modeling do not necessitate recomputing the coefficients of the functionalization. However, if STRAP has major performance updates, the coefficients should be derived with the new models.

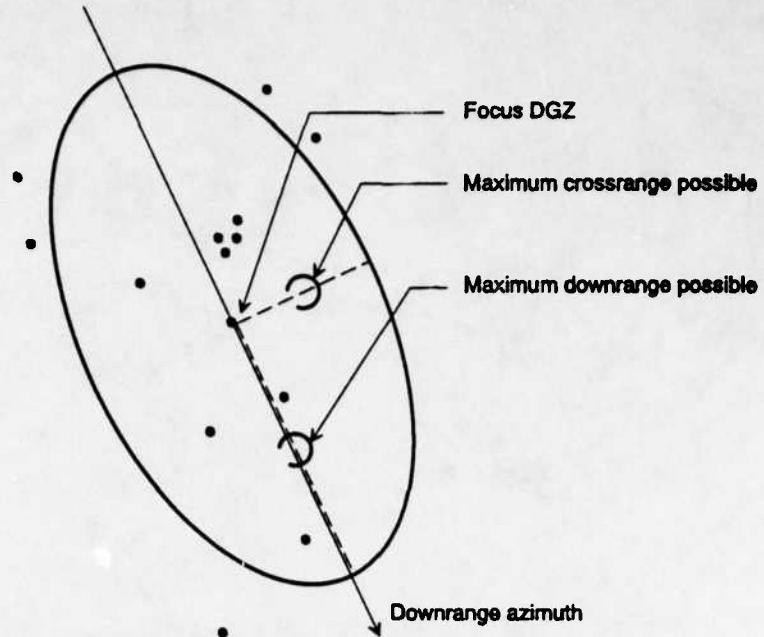


Figure 3. Accessibility domain geometry.

RELOCATABLE TARGET PROCESSING.

The relocatable target (RT) processing incorporated into TAP.3 addresses the problem of RTs operating in a well-defined area around a main operating base (MOB). The TAP program will only assign missiles to RTs if the RTs can be kept at risk while they roam arbitrarily about their operating area. For TAP's purposes, operating areas are defined as circular and contain the MOB as well as the entire area within which the RTs can relocate. The user can specify at runtime the minimum required probability of keeping the RTs at risk. Lower allowed probabilities provide more targeting flexibility.

The process TAP uses to determine if a particular missile is suitable for assigning to RTs is to compare the operating area with a computed "set potential circle." Set potential circles are regions wherein RTs may move and be kept at risk with a given probability: smaller probabilities yield larger circles. The circles are derived from curve-fit functionalizations, and vary with weapon configuration, azimuth, and range from missile to targets. Figure 4 shows the geometry of this scenario. In general, weapons with fewer RBs and shorter ranges to the target area will have larger set potential circles. A missile can be assigned to only those RTs whose operating area lies within the set potential circle for the particular combination. RTs not eligible for a particular missile will be left for other missiles that may be able to cover them due to fewer RBs or shorter range.

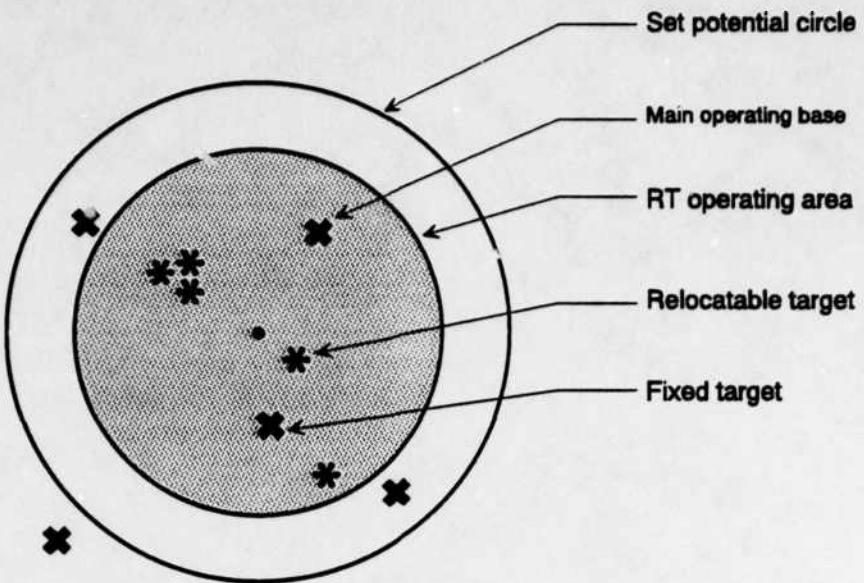


Figure 4. Relocatable target scenario.

Like the domain functionalizations above, the set potential circle coefficients may need to be rederived if the achievability model changes significantly.

MANDATORY MULTIPLE HITS.

With M202, and hence the earlier versions of TAP, a program objective was to cover as many targets as possible. Multiple hits were allowed, but only if they did not conflict with coverage maximization. The mandatory multiple hits (MMH) modification to TAP allows the user to designate certain DGZs as requiring multiple hits. Put simply, sometimes it is better to hit 3 DGZs twice than 6 DGZs once, as shown in Figure 5.

Changes to the code to implement this upgrade followed those already included in M202. The internal valuation schemes were adjusted so that, for specified DGZs, multiple hits were preferred over single hits. Like the RT enhancement, TAP was able to take advantage of work performed on M202 to gain this new capability with a minimum of cost and risk.

MODE 1 SCHEDULER.

The so-called mode 1 scheduler was derived from the Advanced Missile Model (AMM). It creates a launch schedule in which none of the sorties exceeds a maximum allowed fratricide level. In accomplishing this, no constraint is placed on the span of time over which the launches

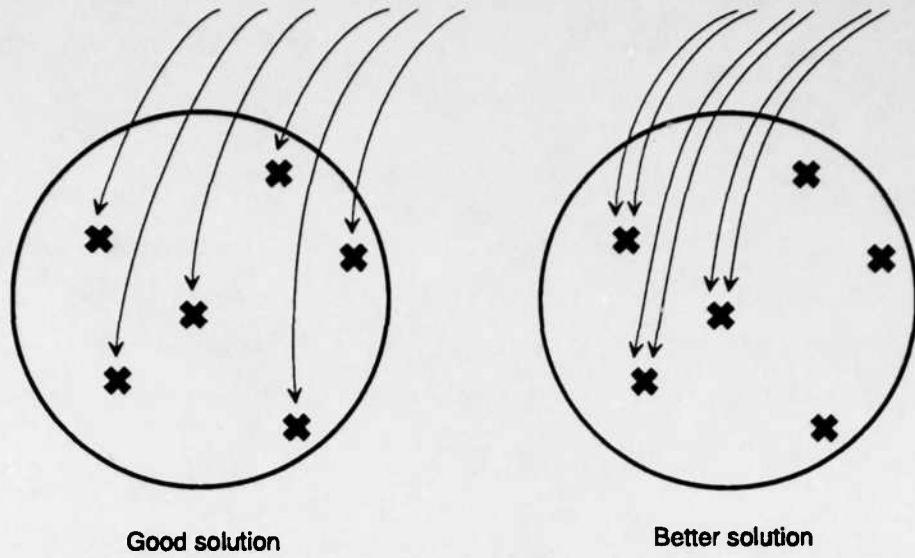


Figure 5. Mandatory multiple hits example.

may occur. The TAP scheduler takes as input assigned missiles and fratricide data. The results reported are the launch time for each missile and the probability of fratricide for each reentry body.

Following are the steps followed to develop the schedule:

- determine fratricide interactions between RBs from all the sorties
- find cycles where RBs may cause fratricide to other RBs that may, in turn, cause fratricide to the former
- order the sorties so those of higher priority are early in the list, hence eligible for preferred launch times
- assign a launch time to each missile such that it does not violate the fratricide constraint
- compute final probability of inter-sortie fratricide for reporting

Each of these functions is described in more detail below.

Exclusion Periods and Cover Pairs.

An exclusion period is the time from when one RB could possibly begin to cause fratricide to another RB, to the time when no further fratricide from the one RB to the other is possible. While

there are exceptions, a general rule is that an RB arriving at its DGZ during its exclusion period will be destroyed before it can complete its mission.

The computation of exclusion periods involves using "stayout zones" that are computed by NWEM and made available to TAP in a data file. These stayout zones contain information about the size and location of regions where a follower RB will be killed by fratricide, and when those regions exist relative to the builder RB. If a follower RB's aimpoint is inside one of these regions, then it will probably be killed unless it is scheduled to arrive at a time when the stayout zone does not cover the DGZ. Figure 6 shows the geometry of stayout zones.

To speed processing, multiple levels of filters (Figure 7) are used to eliminate RB pairs that can easily be determined to have no fratricide interaction. These filters include a maximum exclusion radius where RBs separated by more distance than any stayout zone cannot interact. An arbitrary box around the builder's DGZ further eliminates unwanted DGZs by considering the maximum stayout zone size for the RBs of interest. A maximum exclusion rectangle test then orients a rectangle containing all stayout zones for the RB pair along the follower RB's azimuth and eliminates more DGZs from further consideration. DGZs that still might have fratricide are then evaluated in detail by comparing their locations with each of the dynamic stayout zones. RBs not eliminated by any of these tests are called a "cover pair" and this information is made available to subsequent processes.

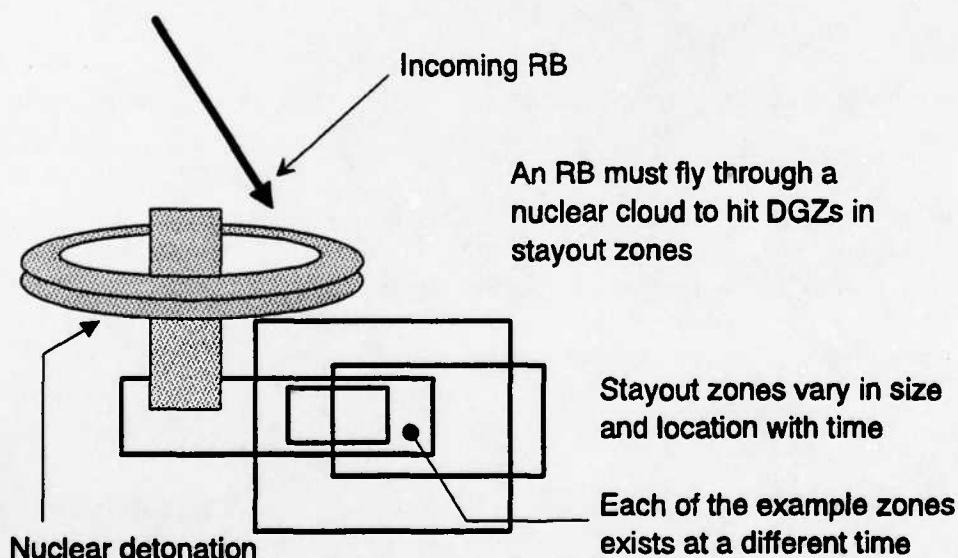


Figure 6. Stayout zone geometry.

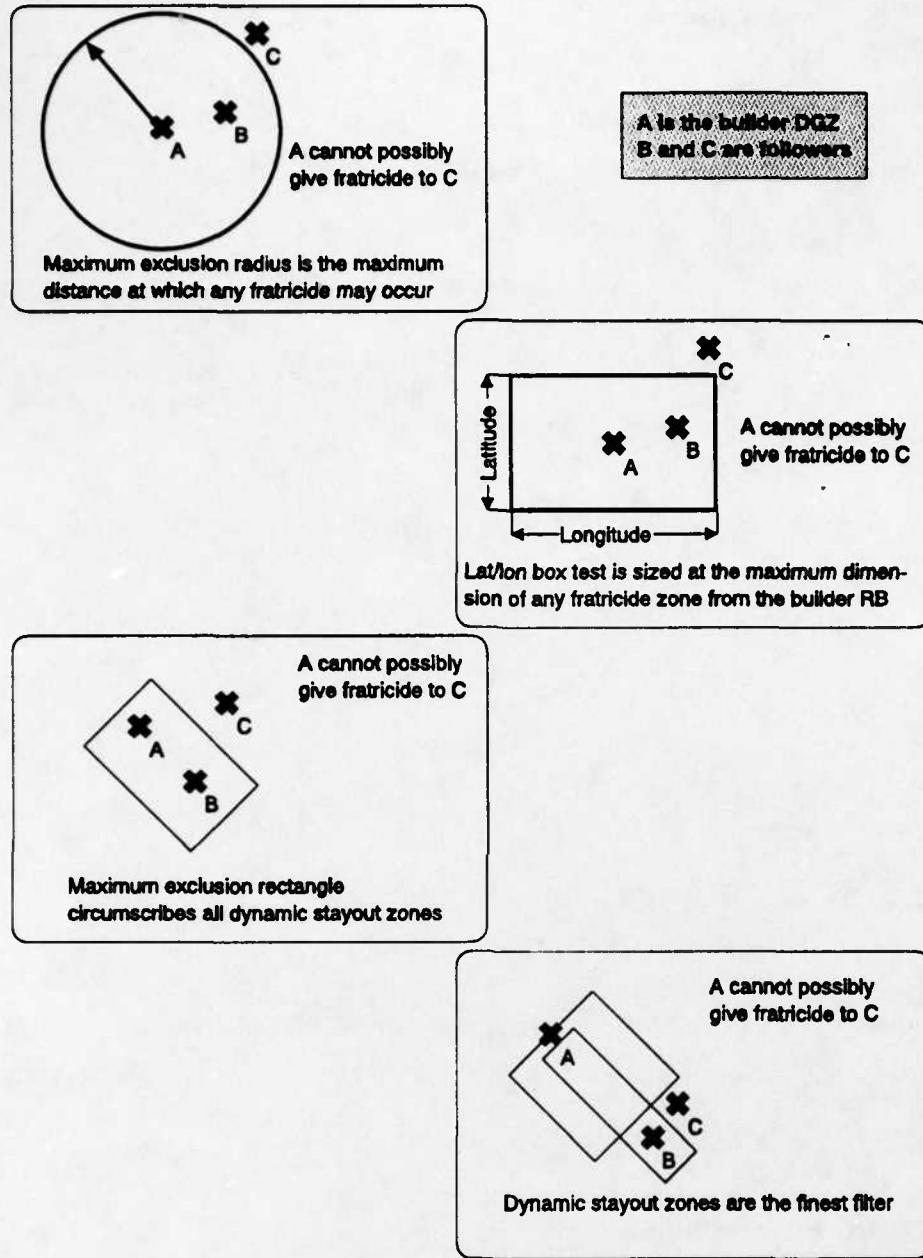


Figure 7. Fratricide filter tests.

Mutual Cycles and Launch Delays.

The problem of fratricide mutual cycles is solved explicitly to minimize overall launch delays. Mutual cycles are chains of covered sorties that loop back on themselves as illustrated in Figure 8. A small cycle in this example is G covering H which, in turn, covers G. These cycles are a problem for the scheduler because the complex fratricide interactions can only be effectively resolved if the cycle is considered as a whole. TAP determines appropriate delays between the sorties in each mutual cycle and passes the deconflicted cycle on for assignment of launch time.

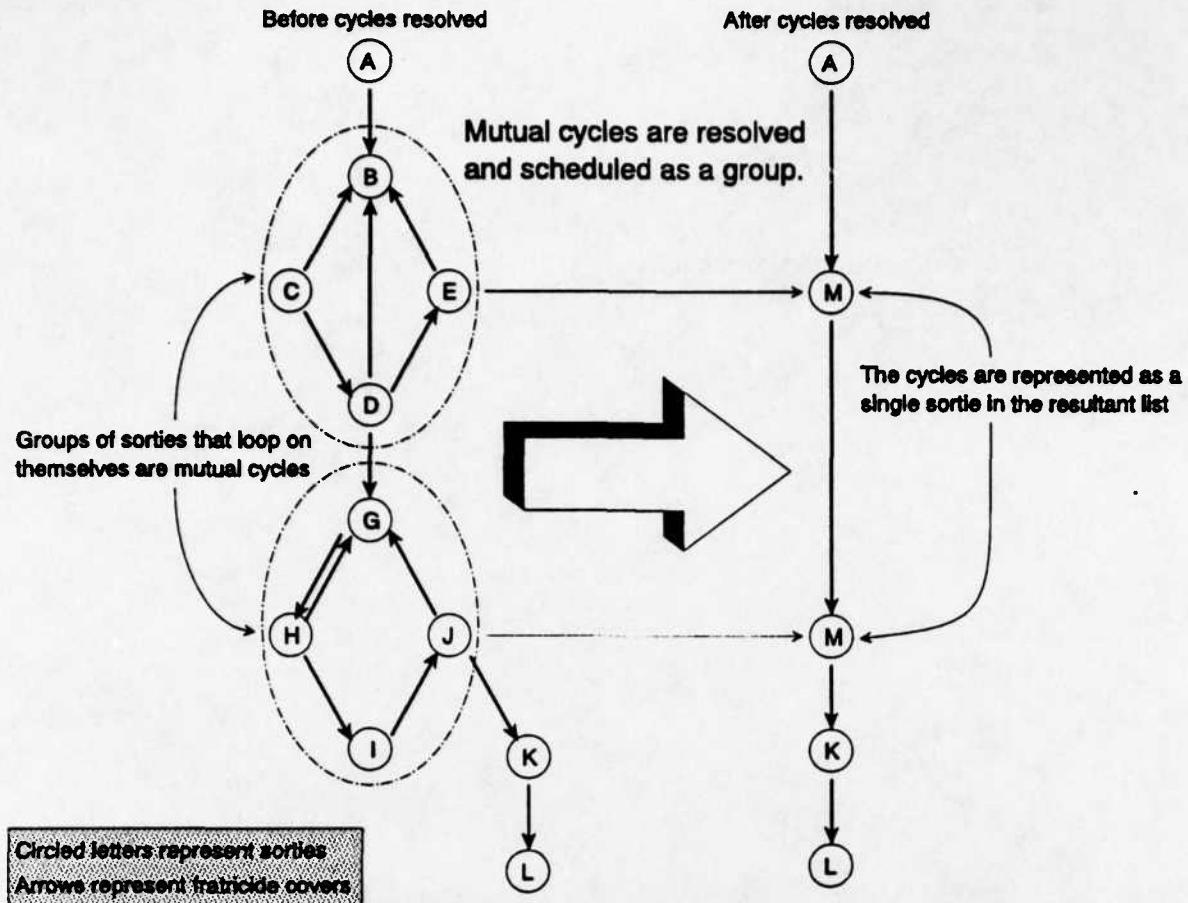


Figure 8. Mutual cycles example.

The cycles are then given launch times as if they were individual sorties. Once the cycle is given a launch time, it is decomposed and each sortie's launch time is established using the delays determined during this step.

Sequence the Sorties for Scheduling.

Once cover pairs and mutual cycles have been determined, TAP creates a list of the sorties to be scheduled, and sorts that list according to user-defined target priorities and the complexity of the surrounding fratricide interactions: more important sorties go first in the list, as do those with less complex interactions. This ordered list of sorties is then ready to have launch times computed.

Assign Launch Times.

In assigning launch times to missiles, TAP takes one sortie at a time from the ordered list prepared in the previous step. It determines an optimum launch time for the sortie that best satisfies the objective of the schedule: either minimum span of launch times, or minimum span of

impact times. If this launch time has fratricide problems, the program searches among nearby times until one is found that doesn't violate the constraints.

Compute Probability of Fratricide.

Once all the sorties have been assigned launch times, the final probability of fratricide is computed. The fratricide function is illustrated in Figure 9. The computations integrate over each exclusion period using the available burst times and exclusion periods for the RB pair.

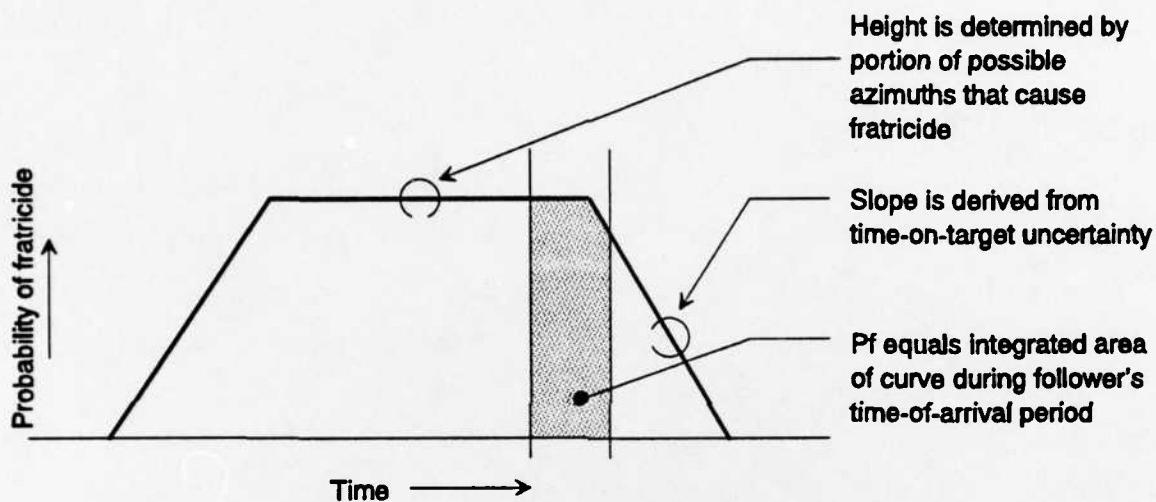


Figure 9. The fratricide function.

SECTION 3

TAP.4 ENHANCEMENTS

The primary enhancement to the fourth version of TAP was a new scheduler mode capable of launching sorties at a predetermined rate. This change was required because in many situations it is desirable to launch a boat's sorties as quickly as possible rather than waiting until all fratricide conflicts have cleared up. In support of this basic requirement, several other features were included in this "mode 2" scheduler. In addition to the new scheduler mode, several enhancements were made to the mode 1 scheduler, mainly to give it the ability to disregard certain fratricide relationships.

MODE 2 SCHEDULER.

The mode 2 scheduler attempts to minimize fratricide conflicts while launching sorties at a user-determined rate. The user can control the objectives and constraints either by package or sub-package. (A package is roughly equivalent to a boat, and a sub-package is a subset of that.) The same fratricide models are used in the mode 2 scheduler as in mode 1. The resulting timing and deconfliction software has the facility for:

- scheduling boats with split launches (several groups of sequential launches) using sub-packages
- user control of the order of sub-packages
- user control of the delay between sub-packages
- user control of the order of packages within the schedule
- specifying explicitly or leaving to TAP the determination of each aspect of the resultant schedule of launches
- user-specified or program-determined delays between packages
- user-defined sub-packages that are scheduled as a group within each package
- determination of times when a sortie could be safely launched if it was not launched at its appointed time
- ability to disregard certain fratricide conflicts

These are each discussed in the following sections.

Fixed Launch Rate.

The mode 2 scheduler plans launches at a user-specified rate. For example, they could be timed to launch once every 60 seconds. The task the scheduler performs, then, is to select the order of launches that will incur the least fratricide.

The approach used to solve this discrete nonlinear minimization problem comes from the discipline of statistical mechanics. The algorithm, Simulated Annealing, tests many possible orderings and drives toward a global minimum by always accepting better results and sometimes accepting worse results. This allows it to escape local minima and strive toward a global optimum solution. (Because of the nature of the problem, a global optimum cannot be guaranteed without examining all possible orderings of sorties, which was impractical in this situation.)

This processing applies to each package or sub-package but not across all sorties. This is because, while sorties within a package may be required to launch at a fixed rate, packages may be launched at arbitrarily different times. The next section discusses how package delays are established.

Inter-Package Delay Timing.

If TAP is directed to determine inter-package delays, it iterates, trying one set of delays and reordering the sorties within the packages to minimize fratricide. It then tries other delays until an optimum set is found. This iterative approach is feasible because of the relatively small number of packages possible in the United Kingdom scenario. When selecting delays, TAP schedules package times that prevent sorties in one package from causing more than the acceptable amount of fratricide to sorties in any other package. Packages may be delayed as long as necessary to eliminate this inter-package fratricide. Other aspects of inter-package processing are similar to those of sub-packages; they are discussed together in the next section.

Sub-Packages.

Sub-packages must be scheduled relative to each other. The user can specify both the order of sub-packages within a package, and the delay for each sub-package. If one or both of these is not specified, TAP will determine it. Figure 10 shows an example of how packages and sub-packages are arranged. If TAP is tasked with determining the order and times of sub-packages, it

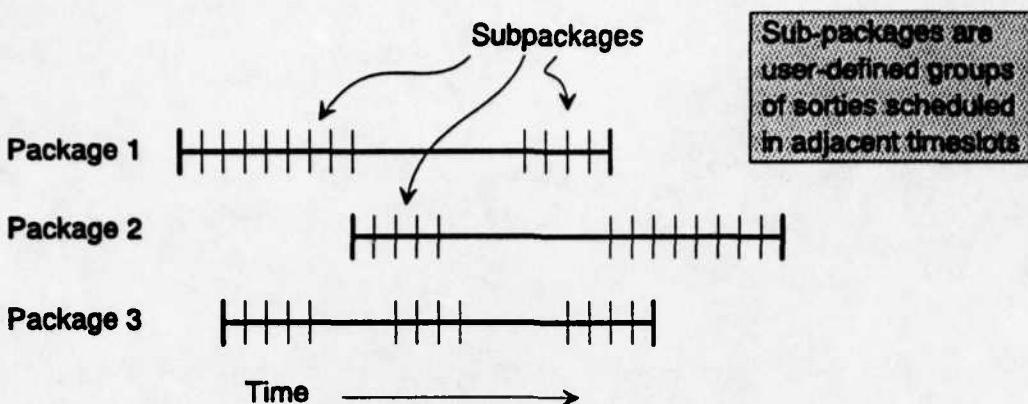


Figure 10. Package and sub-package timelines.

formulates the solution according to the classical traveling salesman problem: pick the order of sub-packages that minimizes the total launch span of the sub-packages. Figure 11 shows the major functions of the mode 2 scheduler and how they interact. Note that each of these functions (package delays, sub-package delays, order of sorties, order of packages/sub-packages) builds on lower-level functions in a highly iterative fashion. For example, if sub-package times and order are not specified, TAP selects an order and posits delay times, then performs the sortie ordering function to minimize fratricide within the fixed launch rate constraint. This solution is evaluated and compared with other iterations of different sub-package orders and different delays.

Preordered Sorties.

The user can establish the order of launch of any or all sorties input to the scheduler. This provides explicit control for areas of high priority and for situations in which other issues besides those considered by TAP affect the desired times on target.

Relaunch Windows.

Once a complete schedule has been derived, TAP can search for opportunities to launch each missile later than its scheduled launch time. These relaunch windows would be useful when a sortie was not launched at its appointed time but needed to be sent on its way at the next time at which that it wouldn't conflict with other missions. TAP computes all windows of opportunity up to the "all clear" time, after which there are no further fratricide considerations. Figure 12 shows an example of relaunch windows.

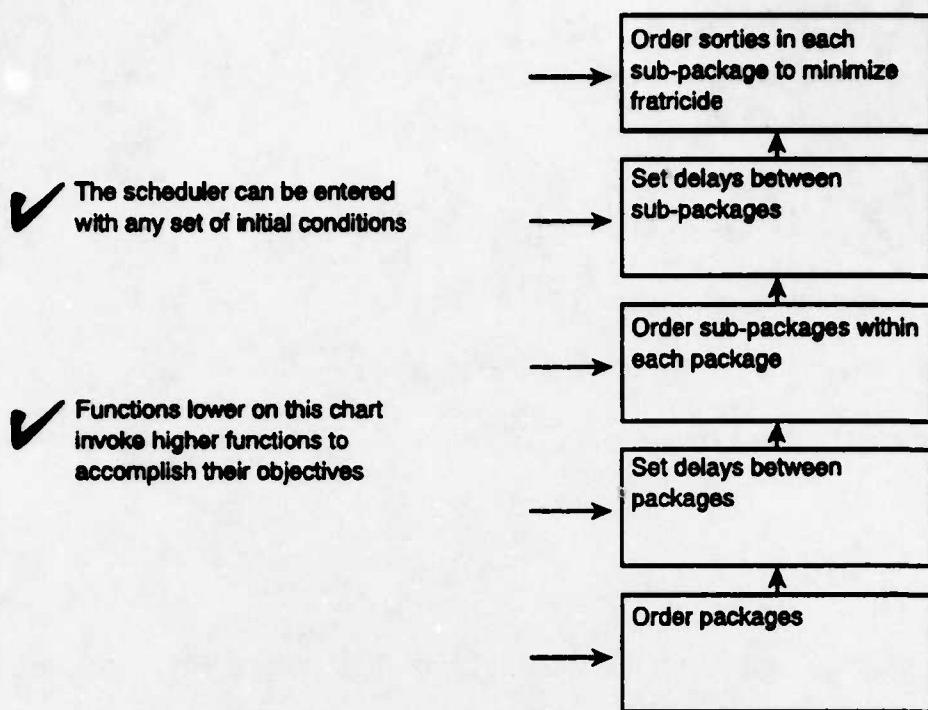


Figure 11. Package and sub-package functions.

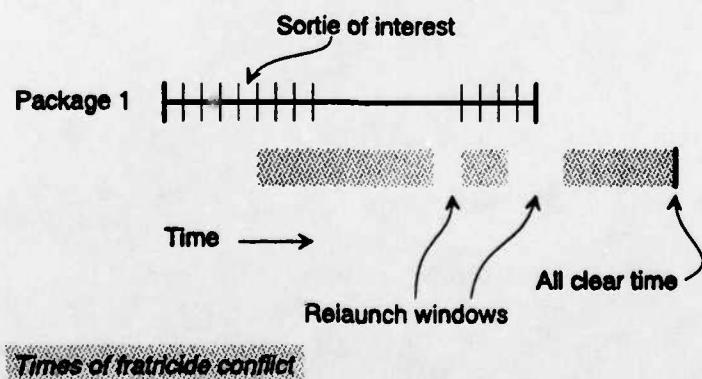


Figure 12. Relaunch windows.

Disregard Certain Cover Relationships.

To provide more control for the planners, the capability to disregard certain fratricide interactions was incorporated into TAP. Three situations can be controlled:

- ignore fratricide between user-specified RBs and all other RBs
- ignore fratricide between all RBs aimed at the same DGZ
- ignore fratricide between all RBs from two or more nominated sorties

If any of these are requested by the user, TAP will consider that there is no fratricide in those situations.

MODE 1 SCHEDULER.

Several minor enhancements were made to the mode 1 scheduler. These included eliminating overlapping launch times and ignoring certain fratricide interactions.

Eliminating Overlapping Launch Times.

In mode 1, the planners could preschedule the launches of specific missiles before submitting the balance to TAP for processing. A change was made for TAP.4 so that any TAP-selected launch times lie outside the timespan of the prescheduled launches for each boat. All program-derived times will be either before the first or after the last prescheduled launch.

Disregarding Certain Cover Relationships.

To provide more control for the planners, the capability to disregard certain cover relationships was incorporated into TAP in the same fashion as for mode 2, above. Three situations can be controlled:

- ignore fratricide between user-specified RBs and all other RBs
- ignore fratricide between all RBs aimed at the same DGZ
- ignore fratricide between all RBs from two or more nominated sorties

If any of these are requested by the user, TAP will consider that there is no fratricide in those situations.

SECTION 4

MAINTENANCE

While the enhancements discussed above compose most of the TAP effort under this contract, some maintenance changes were made to the program to improve its effectiveness. The primary ones are listed below. Additionally, several program anomalies were found and repaired.

The mode 1 scheduler was updated to consider whole boats instead of forces when minimizing the launch span. If a boat had missiles with different numbers of RBs, then those missiles would be in different forces as reckoned by TAP. This change explicitly precludes missiles on the same boat from being assigned the same launch times.

A major factor determining the fratricide stayout zone sizes and locations is reentry velocity. However, NWEM data was selected based only on height of burst and reentry angle. The change to TAP was to select fratricide data using reentry velocity in addition to the other factors, thus improving the fidelity of the fratricide modeling.

In TAP's assignment processing, sorties could be input that were already assigned. These preassigned sorties, however, needed to have all their RVs assigned to DGZs. A change was made to the program to allow the planners to specify only a subset of the RV-to-DGZ tieups, with TAP completing the set of assignments. These partially preassigned sorties would then incorporate the planner's explicit targeting needs, while TAP's completion of them would ensure that general objectives were also met.

There are several curve-fitting functions embedded in TAP. These include a rough estimate of achievability, domain scaling factors, and relocatable target set potential circles. The coefficients included in the first versions of TAP were derived for Trident I missiles. Using the JSTPS achievability program for Trident II, Logicon re-fit the curves. These new functionalizations aid the program by providing better predictors of achievability.

The ability to preassign sorties in TAP assumed default values for a variety of trajectory parameters. However, once missions had been flown through TRITEST (the Trident mission validating program), better trajectory information was available that would eliminate intra-sortie fratricide, among other things. A change was made to TAP to allow input of in-flight spacing and

time-of-flight controls to maintain concurrency with TRITEST. These new inputs ensure accurate time-of-flight information for use during scheduling.

SECTION 5

SUPPORT AND ADVICE

In addition to continuing the development of the TAP software, Logicon performed other support tasks under this contract. These activities included training, documentation, and technical consultation.

TRAINING.

As an integral part of each major software delivery of TAP, a training course was presented. This training was directed primarily at users of the program. The multi-day courses explained the many inputs and controls in TAP and how the program is executed. Further, an explanation of the software was provided, since an understanding of this helps users interpret program results. The training went into some depth in explaining the program's structure and data manipulation. The intent was to assist both the using community and those who will be maintaining and supporting the program in the future.

NWEM SUPPORT.

The Nuclear Weapons Environment Model (NWEM) is a program developed under DNA auspices primarily for use with AMM. In support of TAP, Logicon rehosted the program from the IBM mainframe environment to the VAX. To aid the use of the program, an interactive user interface was developed using a question-and-answer style of data entry. This replaced NWEM's "card column" style of input. A manual was prepared that described the use of NWEM on the VAX with the new interface. To help DGSWS understand the functioning of NWEM, Logicon held technical discussions between weapons effects experts (including an NWEM developer) and DGSWS personnel. This interchange aided understanding of what nuclear effects NWEM models and how it models them.

TECHNICAL INTERCHANGE.

During the course of this effort, Logicon led sessions in detailed reviews of design and implementation of the many enhancements to TAP. These sessions helped the developers understand the program's objectives and helped ensure that DGSWS was provided software that met their needs. Each software delivery was accompanied by a team of developers who worked

with DGSWS to install the program and test it at the site. These extended periods also aided the staff at DGSWS by giving them an opportunity to discuss and review TAP issues with developers in an informal environment.

Reports were also provided regarding other issues in which Logicon is involved. Ongoing research in algorithmic areas was reviewed, including discussions of the use of neural networks in mission planning, and the application of the Lin-Kernighan optimization methodology. Reports were made of concurrent updates being performed on M202 for JSTPS. Several of these M202 developments were subsequently incorporated into TAP. Further, Logicon responded to various requests for analysis of potential program modifications, including evaluation of program impact and estimates of effort required.

SECTION 6

CONCLUSION

Two new versions of TAP were delivered to DGSWS under this contract. The TAP program with these updates is a very flexible and highly reliable system that leverages its M202 ancestry to provide a powerful set of software that is mature. Many new features were added, including a timing and deconfliction capability that allows for two different scheduling assumptions.

The work was completed according to schedule, within budget constraints, and to the satisfaction of the Ministry of Defence.

APPENDIX

GLOSSARY OF TERMS

The following are selected word definitions for terminology commonly used.

| | |
|---------------|--|
| Achievability | The ability of a missile to strike given aimpoints. It is affected by weapon system, range to targets, launch latitude, launch azimuth, among other factors. |
| AMM | Advanced Missile Model. AMM is a program used by the Air Force to model a variety of strategic situations. TAP's mode 1 scheduler was derived from AMM. |
| Builder RB | The RB that potentially causes fratricide. See also Follower RB. |
| Cover | A fratricide relationship between two RBs. An RB is said to cover another RB if it can cause fratricide to that RB. |
| | Also, a missile assignment. A missile covers a DGZ if it is assigned to the DGZ. |
| DGZ | Desired Ground Zero. An aimpoint. |
| DGSWS | Director General Strategic Weapons Systems. The British Ministry of Defence organization that directed the development of TAP. |
| Domain | An elliptical region that quantizes the capability of a weapon to cover targets. It is used during missile assignment to direct the flow of processing. |
| Follower RB | The RB that potentially receives fratricide damage. See also Builder RB. |

| | |
|------------|---|
| Fratricide | Damage from one friendly weapon to another. Fratricide damage is caused by blast, dust and debris, radiation, and other effects. It prevents the follower RB from detonating according to plan. |
| JSTPS | Joint Strategic Target Planning Staff. The U.S. military organization charged with developing the Single Integrated Operating Plan (SIOP) for a strategic nuclear war. |
| M202 | Missile Application Program. The operational program used at JSTPS for assigning strategic ballistic missiles to aimpoints. |
| MMH | Mandatory multiple hits. A TAP assignment control that directs the program to prefer hitting DGZs several times rather than hitting a larger number of DGZs singly. |
| MOB | Main operating base of a group of relocatable targets. |
| NSWC | Naval Surface Warfare Center, the U.S. organization that developed the Trident II achievability model used in TAP. |
| NWEM | Nuclear Weapon Environment Model. This DNA program that determines fratricide damage. The results are used by TAP. |
| Package | A set of sorties scheduled as a group. Typically, a package is equivalent to the set of missiles in a single submarine. |
| RB | Reentry body. The nuclear warhead from a ballistic missile. Sometimes referred to as a reentry vehicle (RV). |
| RT | Relocatable target. An RT is a DGZ that moves, making it more difficult to target. An example is a train-based missile launcher. |

| | |
|----------------------|--|
| Scheduling | The process of assigning launch times to individual missile sorties. The scheduling process is driven by planner-directed time constraints, and fratricide minimization. |
| Set potential circle | A region wherein RTs may move and be kept at risk with a given probability. A smaller probability yields a larger circle. |
| Sortie | A missile and its mission. Sometimes used to refer solely to the missile. |
| Stayout zone | A fratricide region wherein a builder RB will destroy a follower RB if the follower arrives within a given timespan. Typically there will be several stayout zones for each RB pair, one for each of a set of times. |
| STRAP | Simplified Trident Rapid Achievability Predictor. This is a program that models the trajectory of Trident sorties and determines whether a particular missile can hit a given set of DGZs. |
| Sub-package | A subset of sorties within a package that are scheduled as a group. Sorties within a sub-package are launched in succession with no pauses between each launch. Sub-packages may have pauses between them. |
| TRAP.2 | Trident Rapid Accessibility Program. An achievability program used by JSTPS to model Trident II trajectories. |
| TRITEST | Trident Tester. TRITEST uses STRAP and other data to determine optimum trajectory parameters to achieve the mission goals of each sortie. |

**END
FILMED**

DATE:

7-91

DTIC